SIZE AND COMPOSITION OF THE MACKENZIE WOOD BISON POPULATION IN 1989

Northwest Territories Renewable Resources

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C. C. GATES
DEPARTMENT OF RENEWABLE RESOURCES
GOVERNMENT OF THE NORTHWEST TERRITORIES

N. C. LARTER
THE ECOLOGY GROUP
DEPARTMENT OF ZOOLOGY
UNIVERSITY OF BRITISH COLUMBIA

P. E. KOMERS
DEPARTMENT OF BIOLOGY
UNIVERSITY OF SASKATCHEWAN

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ABSTRACT

Wood bison introduced to the Mackenzie Bison Sanctuary in 1963 increased at a mean exponential growth rate of $\underline{r}$ = 0.215 during the period 1964 to 1987. The rate of population growth has slowed since 1975. However, with the continued increase in herd size a controlled hunt was allowed for the first time during the 1987/88 hunting season. Four bison were killed from a quota of 20 males. Twenty males were killed in 1988/89 when the quota was increased to 40 males. A census was conducted in March 1989, employing a combination of total counts and sampling to estimate bison numbers. The number of bison estimated in the sampled strata was 1048 $\pm$ 229 (s.e.). Total population size was estimated to be 2431 bison based on census results. The calculated 95% confidence range for the annual exponential rate of increase ($\underline{r}$) between 1987 and 1989 based on the census estimate was 0.07 to 0.26.

A demographic model was constructed to provide alternative estimates of population size and rate of increase, based on the 1987 total count and demographic parameters. With this method the estimated size of the herd in March 1989 was 2040 and a growth rate for 1988/89 of $\underline{r}$ = 0.11 was calculated, accounting for hunting losses and estimated natural mortality. The accidental loss of 177 bison caused by deteriorating ice on Falaise Lake in May 1989 resulted in a total population of 1863 in June 1989 and a net rate of increase of $\underline{r}$ = 0.02 for 1988/89.

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INTRODUCTION

The Mackenzie wood bison (*Bison bison athabascae*) herd is the largest population of this subspecies of bison, representing approximately two thirds of all wood bison (Wood Bison Recovery Team 1987). The herd originated with the transfer of 18 wood bison captured in northern Wood Buffalo National Park in 1963. During the period 1964 to 1987 the herd grew at a mean exponential rate of $r = 0.215$, reaching 1718 bison in 1987 (Gates and Larter 1990). Herd growth declined after 1975, reaching a lower rate of $r = 0.103$ in 1986-1987. Gates and Larter (1990) speculated that predation was an important factor contributing to the slowing rate of growth. With the continued positive growth of the herd, a controlled hunt was allowed for the first time during the 1987/88 hunting season; four bison were killed from a quota of 20 males. The quota was increased to 40 males in 1988/89; 16 tags were allocated to the Fort Providence Hunters and Trapper's Association, 12 to the Dogrib Tribal Council and 12 were offered to eligible resident NWT hunters.

The Department of Renewable Resources is involved in a number of cooperative studies on the ecology of the Mackenzie wood bison herd. Among these, periodic censuses and surveys are undertaken to estimate the size and structure of the herd. This report provides the results of a late winter census and a post-calving composition survey in 1989 and, based on a demographic model, provides an evaluation of the impact of mortality from regulated hunting and accidental deaths during 1988/89.

METHODS

Population Estimates

A Cessna 185 fixed-wing aircraft was used for a census during March 28 through April 3, 1989. The census zone (Figure 1) was stratified based on prior knowledge of the distribution and density of bison obtained from radio-telemetry relocation flights. An effort was made to count all bison in the areas of Falaise Lake, Boulogne Lake, Calais and Dieppe lakes, and the area near Mink Lake where bison were expected to be concentrated. These "total count areas" were searched intensively from the air for bison. Large groups of bison (>20) were photographed to assure an accurate count.

A limit to the census zone was set in the northern portion of the Mackenzie Bison Sanctuary that reflected the presumed northern limit of the herd. A general reconnaissance flight was undertaken north of this area to locate additional bison. Bison counted there were included in the total population estimate.

The remainder of the census zone was sampled using a stratified systematic transect survey. Evenly spaced transects were established for each of the sampled strata. Sampling intensity (distance between transects) was optimally allocated based upon available air time and expected bison density. The transects ran across the shorter dimension of each stratum to

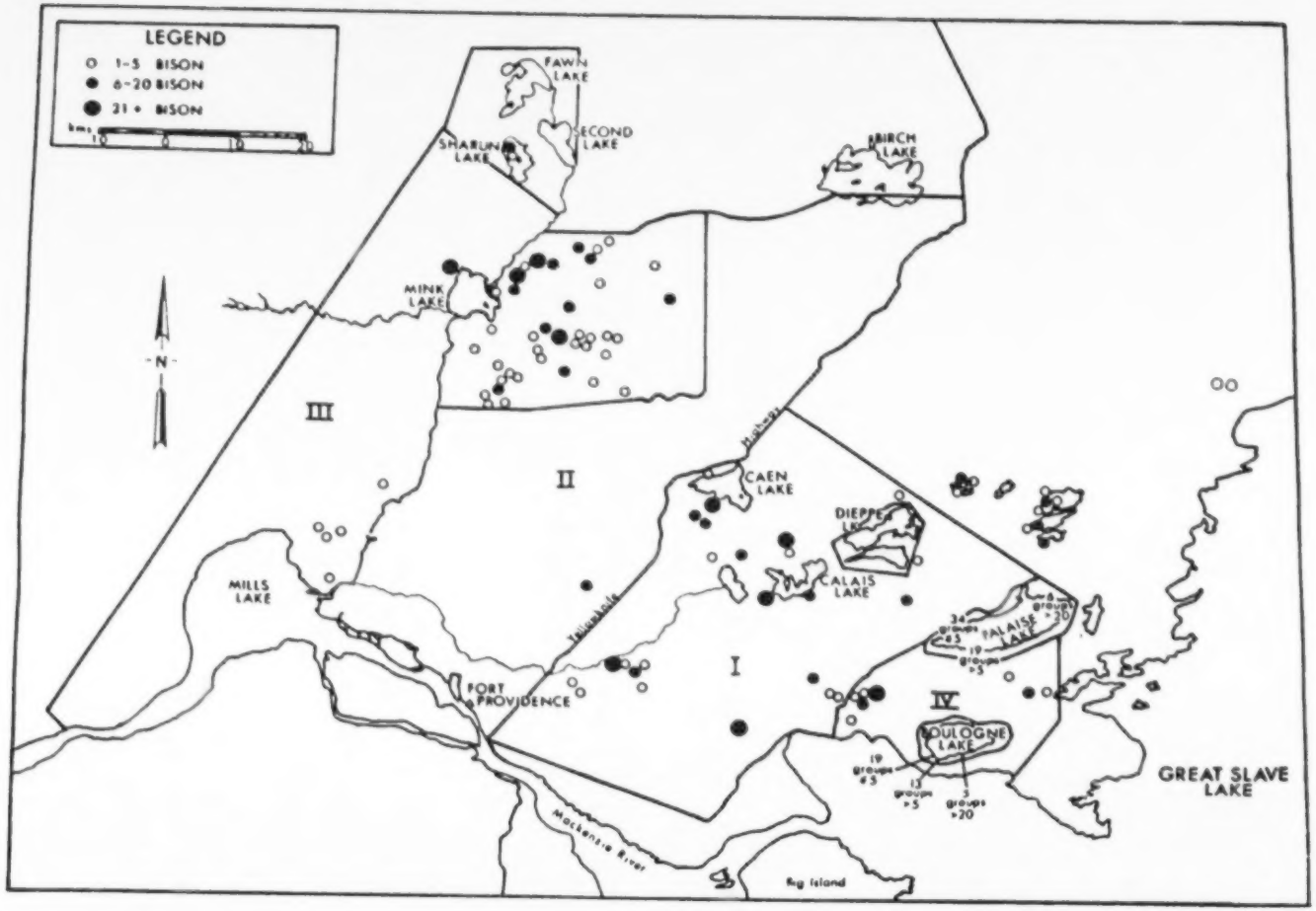

Figure 1. Map of the study area showing stratification used for the March/April 1989 census and location of bison observed on transects and in total count areas.

increase the number of sampling units and reduce sampling error (Norton-Griffiths 1978). Altitude was maintained at 500 m aboveground level. Strut markers were positioned according to the formula provided by Norton-Griffiths (1978) to enable observers to monitor a transect width of 500 m on either side of the aircraft. Population size and variance was calculated for sampled strata following method two described by Jolly (1969). A polar planimeter was used to calculate stratum areas. The survey crew consisted of a pilot, a navigator and two observers. Bison observed on transect were recorded separately from those observed off transect.

A demographic model was constructed to provide an alternate estimate of population size based on yearling:cow ratios observed in 1988 (ratio = 0.23, Gates and Larter 1990) and 1989 (this report) and assumptions about adult survivorship (males = 0.90, females = 0.97) and adult sex ratio (0.83 M: 1 F, Gates and Larter 1989). The 1987 total count was used as an initial population size in the model, divided into two population centres, Mink Lake (n=487) and Mackenzie Bison Sanctuary (n=1231). An initial stable population age structure was generated by applying the average rate of growth of the herd between 1964 and 1987 (Gates and Larter 1989). The model incorporated mortality from hunting in 1987/88 and 1988/89 and from deaths in spring 1989.

Composition Surveys

During June 10 through 23, bison were classified to determine population composition. Male bison ≥ 2 years were classified in the following categories:

Class I: Approximate age 2-3 years. Juvenile males, characterized by a body size similar to adult cows, with horns curved straight up (spike horns).

Class II: Approximate age 4-6 years. Subadult males, characterized by large body size, horns curved straight up (spike horns), frontal display hair not well developed and not filling space between horns.

Class III: Mature males (≥ 5 years), characterized by large body size and curved horn tips, frontal display hair filling space between horns.

Class IV: Old males, similar to mature males but with bilaterally broomed horns.

Other categories used for classifying bison were the following:

Calves: Reddish-brown pelage and very small body size.

Yearlings: Pelage the same colour as adults but with body size intermediate between calves and adult cows and short, straight, goat-like horns.

Cows: Body size much larger than yearlings, horns variable in length, thinner than in males, and curved upwards.

Observers were positioned near groups of bison by helicopter or with all-terrain vehicles. Bison in the vicinity of Mink Lake were classified on one day, June 21. Bison in the Mackenzie Sanctuary were classified on 10 separate days between 10 June and 23 June. The chi-square test was used to compare frequencies of sex and age classes between areas.

Age Structure of the Harvest and Natural Deaths

The ages of bison killed by hunters or found dead in spring 1989 were estimated from tooth replacement sequences, to the age of 3 years after which permanent teeth are erupted (Fuller 1959, Wegrzyn and Serwatka 1984). Permanent incisor teeth (I_1) were collected for later age determination by histology; histological analysis is currently in progress. Birth date was standardized to June 1 for the purpose of age structure analysis.

RESULTS

Population Estimates

During the census the greatest concentrations of bison were seen on Falaise Lake, Boulogne Lake and in the vicinity of Mink Lake (Table 1). Bison in the total count areas accounted for approximately half of the estimated total population size.

Stratum I contained the greatest density and number of bison among the sampled areas (Figure 1). The coefficient of variation of the estimate for this area was the lowest of any stratum (Table 2).

The total number of bison observed in the sampled strata, both on and off transect, was 397. The total observed during the census was 1780. The number of bison estimated in the sampled strata was 1048 $\pm$ 229 (s.e.); the 95% confidence interval for the estimate was 602 to 1494. Total population size was estimated to be 2431 bison, including bison counted in the total count areas and bison numbers estimated in sampled strata.

By combining the total count data with estimates from the sampled areas, the 95% confidence range for the population estimate for March/April 1989 was between 1985 and 2877 bison. Based on these limits the calculated range for the annual exponential rate of increase (r) between 1987 when 1718 bison were counted and 1989 was between 0.07 and 0.26.

Table 1. The number of bison observed in total count census areas in March 1989.

Area	Number counted
Dieppe Lake	0
Northern Mackenzie Sanctuary	46
Sharun and Fawn lakes	10
Mink Lake	249
Boulogne Lake	415
Falaise Lake	663
Total	1383

Table 2. Bison population estimates for sampled strata.

Stratum	N	Sampling Intensity(%)	Density (km^{-2})	Estimate	S.E.	C. V.
I	22	37	0.29	593	151	0.26
II	19	18	0.12	209	128	0.61
III	14	14	0.03	78	71	0.91
IV	13	35	0.44	168	87	0.52

Population size (N = 2040) estimated with a demographic model that excluded 1989 spring mortality was close to the lower limit of the 1989 95% confidence range (Table 3). Population growth during 1988/89 estimated by this method would have been $\underline{r}$ = 0.11. However, with the spring deaths in 1989, population size in 1988/89 was nearly stable ($\underline{r}$ = 0.02, N = 1863) and the Mackenzie Sanctuary component of the population declined slightly (Table 3).

Population Composition

The ratio of calves:cows in the Mackenzie Sanctuary area was 0.44 and the yearling:cow ratio was 0.22 (Table 4). The calf:cow ratio at Mink Lake (0.48) did not differ significantly from the ratio for bison classified in the Mackenzie Sanctuary ($\underline{X}^2$ = 0.11, df=1, $\underline{P}$ > 0.05). The yearling:cow ratio was slightly higher at Mink Lake (0.32) than in the Sanctuary, but the difference was not significant ($\underline{X}^2$ = 2.03, df=1, $\underline{P}$ > 0.05). The combined ratio of calves:cows for the two areas was 0.45 and the combined yearling:cow ratio was 0.24.

The ratio of adult ($\geq$ 2 years) males:females was significantly higher for bison in the Mink Lake area than in the Mackenzie Sanctuary, 1.50 vs. 0.83 respectively ($\underline{X}^2$ = 16.18, df=1, $\underline{P}$ < 0.005). Male populations differed significantly in age structure ($\underline{X}^2$ = 41.74, df=3, $\underline{P}$ < 0.005); there was a greater

Table 3. Results of a demographic model of growth of the Mackenzie wood bison population for 1987/88 and 1988/89, with and without spring mortality in 1989.

	Number of bison by area			Exp. rate of increase		
Year	ML	MBS	Total	ML	MBS	Total
1987	487	1231	1718	0.10	0.10	0.10
1988	521	1314	1835	0.07	0.07	0.07
1989[a]	586	1454	2040	0.12	0.10	0.11
1989[b]	586	1282	1863	0.12	-0.02	0.02

[a] estimate without spring mortality

[b] estimate with spring mortality

ML - Mink Lake

MBS - Mackenzie Bison Sanctuary

Table 4. Composition of bison classified in the Mackenzie Sanctuary and at Mink Lake in June 1989.

		Age class of Males						
Area	Date	I	II	III	IV	Cows	Calves	Yearlings
Sanctuary	10	0	14	45	0	54	27	13
	12	6	25	12	4	13	6	4
	13	9	5	9	4	45	12	9
	15	27	10	13	2	128	62	32
	16	12	25	22	4	91	36	17
	17	6	17	20	1	35	9	7
	19	3	8	6	0	16	6	4
	20	3	5	8	0	20	10	7
	22	13	16	9	1	72	44	14
	23	6	11	22	3	15	4	3
Total		85	136	166	19	489	216	110
Mink Lake	21	15	22	107	6	100	48	32

proportion of class III males at Mink Lake, 71% of males compared with 41% in the Mackenzie Sanctuary ($X^2 = 39.43$, df=1, $P < 0.05$).

Results of the 1988/89 Hunt

Twenty male bison were killed by hunters in Wildlife Management Zone G/2-1 during the 1988/89 hunting season. Eighteen were mature males (class III or IV) and two were class II males. Eight bison were taken under the Fort Providence quota, two under the Dogrib Tribal quota and ten resident hunters were successful.

Department of Renewable Resources staff supervising the hunt in 1988/89 reported that many hunters wanted to kill young males for meat, rather than seeking a trophy age animal ($\geq$ 5 years). However, young males (age classes I and II) were frequently unavailable to hunters owing to their patterns of social and flight behaviour. Mature males were noted to be less responsive to hunters approaching on snowmachines than were cows and juvenile bison. While mature males were solitary or occurred in very small groups, young males were associated with larger cow/juvenile groups. The latter are known from the authors' experience to be highly responsive to human disturbance, fleeing readily at the sight or sound of snowmachines.

All segments of the population were in the vicinity of the areas used by hunters in late winter as illustrated by the distribution of bison a few days after hunting ceased (Figure 1).

Mortality in Spring 1989

In mid-June 1989, numerous dead bison were seen floating in one to two metres of water around the perimeters of two large ponds located on the north and south sides of Falaise Lake basin. The carcasses were intact. Only two carcasses had been scavenged; two bald eagles (Haliaeetus leucocephalus) were seen feeding on them. On close examination all carcasses showed evidence of lacerations and bruising on the face, chest, shoulders, thighs and flanks. From the lesions, condition of the carcasses and location of the dead bison, we concluded that the animals had died while struggling in deteriorating ice during spring thaw in late April or early May 1989. Dead bison were not found on other lake beds in the Mackenzie Sanctuary or at Mink Lake.

A total of 177 carcasses was counted. Sex and age class was determined for 173 animals (Table 5). There were nearly equal numbers of male and female yearlings (11 months old) in the sample. Females were more numerous than males in the older age classes. There were no dead males in the $\geq$ 47 month age class, yet this age category contained the greatest number of females.

The ratio of yearlings (11-13 months) to cows ($\geq$ 23 months) was higher in the sample of dead bison than among living bison classified in June, 0.54 vs. 0.22 respectively ($X^2 = 59.25$, df=1, $P < 0.005$).

Table 5. Sex and age classes of bison found dead in Falaise Lake in June 1989.

	Age in months				
Sex	11	23	35	≥ 47	All
Males	28	16	6	0	50
Females	25	29	15	54	123

DISCUSSION

Population Trend and Composition

Prior to 1989, estimates of the size of the Mackenzie wood bison herd were determined by total counts. Since its introduction in 1963, the range of the herd has increased with population size, expanding to over 8,000 km^2 in 1987 (Gates and Larter 1990). Accordingly, total counts have increased in cost and have become more difficult to conduct. In 1989 a combination of total counts in high density areas and sampling in areas of lower density improved census efficiency by reducing the amount of time required to census the large area. However, interpretation of population trend based on sampling estimates was less straightforward than when based on total counts, owing to the wide confidence interval of the estimate.

Increasing sampling intensity is one of several methods that may be used to reduce variance. However, sampling intensity was near the upper logistical limit in strata I and IV (ca. 35%); any further increase would have resulted in errors from recounting bison moving among transect paths. In stratum II increasing sampling intensity may have reduced the variance. Density in stratum III was very low and distribution was restricted to a small area so that a total count would probably have been a more suitable method there.

Gates and Larter (1990) calculated an exponential rate of growth of 0.103 in 1987 and showed that the rate of growth of the herd was slowing. Without considering the high mortality in spring 1989, the rate of growth projected from the demographic model was consistent with the observed trend and the estimate of population size from the model was within the 95% confidence interval of the 1989 census estimate. Gates and Larter (1990) suggested that in recent years, declining calf survival has been the main factor contributing to the decrease in the growth rate of the Mackenzie wood bison herd.

The death of 177 bison in spring 1989 had a significant impact on herd growth, decreasing it to near stability for 1988/89. This type of mortality has not been seen before in the Mackenzie Bison Sanctuary, yet in Wood Buffalo National Park bison frequently die from falling through thin ice on lakes and rivers (D. Huisman pers. comm.). Exceptionally high water levels at Falaise Lake in 1988 may have been a contributing factor. A heavy snowpack in winter 1987/88 followed by record precipitation in summer 1988 caused a rise in the standing water level in lakes in the Mackenzie Bison Sanctuary. In other years, the centre of Falaise Lake has provided a large expanse of wet meadow vegetation that the bison utilized heavily during the winter months and to a lesser extent at other times of the year.

From the distribution of the dead bison it was apparent that in the spring, cows and juveniles encountered deteriorating ice in the areas of persistent standing water on the lake bed. The

highly skewed sex ratio among dead mature bison is not readily explained. Mature males were evidently able to avoid entrapment in the deteriorating spring ice while yearlings were apparently the most vulnerable age class. The accidental loss of bison owing to unfavourable ice conditions cannot be prevented and may reoccur in future years, particularly if the water level in Falaise Lake does not subside.

The higher proportion of males seen at Mink Lake in June may reflect a seasonal change in distribution of mature males. Females exhibit greater philopatry than males, a consequence of greater direct investment in offspring and the requirement for predictable availability and dispersion of food resources (Gates and Larter 1990). Limited movements of radio collared females have occurred between Mink Lake and the Mackenzie Bison Sanctuary (unpubl. data). In contrast, mature males range further than females (personal observations of radio collared bison) and are typically the only class of bison found in peripheral areas (Gates and Larter 1990). Increased movement of mature males during the rutting season could result in changes in the sex ratio and age structure observed in the two areas in June, as males search for female/juvenile groups throughout the herd's range.

Mature males are the primary colonizers of new habitat (Gates and Larter 1990). The high proportion of males in the Mink Lake area may favour an increased rate of discovery and occupation of new range. However, the limits to continued

population growth will depend on the availability of unoccupied favourable habitat. A research program employing remote sensing satellite technology is being undertaken to assess the availability and distribution of favourable habitat adjacent to the area currently occupied by bison.

The 1988/89 Harvest

Avoidance responses by cow/juvenile groups to snow machines and hunters explains the apparent lack of availability of young males to hunters during the 1988/89 hunting season. Similar avoidance responses have been reported for elk (Cervus canadensis) in the Rocky Mountains in Alberta (Morgantini and Hudson 1979). We suggest that the intensity and duration of avoidance behaviour can be substantially reduced by restricting the use of motorized vehicles for the purpose of hunting in areas where bison characteristically aggregate during the winter. The main areas are Falaise and Boulogne lakes. Reduction in disturbance to female/juvenile herds in these areas would allow consecutive hunting parties a greater opportunity to locate bison, particularly young males.

The harvesting of males across a wider range of age classes than occurred in the 1988/89 season would reduce the risk of decreasing the ratio of mature males:females to the critical threshold below which conception rates may be affected. At present the critical breeding sex ratio for free-roaming wood

bison is not known. Factors that determine the critical ratio may include the number of females that a male can fertilize during the rut, dominance relationships among males, duration of the rutting season and mobility of the sexes during the rut (Caughley 1977). A research project was initiated in 1989 on the breeding behaviour of wood bison that will provide facts useful for evaluating optimal age and breeding sex ratios for wood bison.

RECOMMENDATIONS

1. The hunting zone for wood bison for the 1989/90 season should remain the same as in 1988/89. Hunting activity in the Mink Lake area may disrupt the natural expansion of the herd into adjacent range.

2. The quota for 1989/90 should remain at 40 males. This will not seriously affect the rate of growth of the herd. Female harvesting would suppress herd growth.

3. Age composition of the male only harvest should be monitored and the impact of harvesting on standing age structure evaluated to ensure that the ratio of mature males:females remains above the critical level in the long term.

4. Access by motorized vehicles for the purpose of hunting bison should be restricted in zone G/2-1 on Falaise and Boulogne lakes.

5. Every spring a survey should be made to document accidental deaths.

6. Annual composition surveys should be continued to monitor yearling:cow ratio and adult sex ratio. Life table analysis

using demographic data provides an alternative estimate of population growth to that derived from census estimates.

7. Research to improve census accuracy and precision should continue. Specifically:
-censuses should continue to be carried out in late March;
-a total count should be conducted in strata III and IV;
-sampling intensity should be increased in stratum II;
-radio telemetry should be used to test visibility bias (Samuel et al. 1987).

Editors note: recommendations pertaining to the 1989/90 hunt were in accordance with considerations of the Denendeh Conservation Board and were adopted by the Department.

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